



Mitigating Chemical Engineering Design Team Miscommunications with Knowledge of Myers-Briggs Type

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Abstract

The differences between successful and unsuccessful engineering teams seem quite stark on paper. The quality of deliverables like presentations or reports, the interactions of the team members, and the value of questions asked to instructors become increasingly worse as teams collapse. But are these teams really so different from their more successful peers? And what can instructors and the teams themselves do to mitigate difficulties and avoid complete team breakdown? To answer these questions, we investigated the engineering teams in a chemical engineering design capstone course for seniors. We assessed the possibility that the differences, rather than being due to team demographics or GPA discrepancies, were actually due to minute personality type differences among team members. We gave students the Myers-Briggs Type Indicator® (MBTI)¹ at the beginning of the course, but did not reveal their types to them so that they would not modify their behavior based on that knowledge. Throughout the course, the instructor kept notes on student interactions during team meetings and presentations. At the end of the course, we analyzed the instructor's team interaction notes, the students' peer evaluations of one another, and samples of student work for evidence of MBTI type-related difficulties over the course of the semester. We found that teams experienced difficulties related to all four of the MBTI dichotomies which proved to be detrimental to team success, both perceived and actual. Based on our results, we recommend familiarizing students with their MBTI type and the differences between each of the four dichotomies in their first year engineering courses. Knowledge of their MBTI type and the types of others, as well as the different ways in which individuals function, may mitigate the minute miscommunications related to type that contribute to the unexpected failure of some engineering teams.

Background and Motivation

The Myers-Briggs Type Indicator® (MBTI)¹ has a long history of research associated with MBTI type. The instrument used today resulted from Myers' and Briggs' modifications to the work of Jung on psychological typing.² The instrument uses forced choice questions to assign a four letter type based on an individual's preferences in responses. Each letter represents the natural preference of the individual between a dichotomy of personality types in relation to a particular mental process. These dichotomies and their definitions can be seen in Table 1.³

Table 1. MBTI preference definitions by corresponding dichotomy and mental process.

Dichotomy	Mental Process	Preference	Definition
Extraversion (E) or Introversion (I)	Where we prefer to focus our attention and get our energy	Extraversion (E)	Preference to direct energy and attention outward
		Introversion (I)	Preference to direct energy and attention inward
Sensing (S) or Intuition (N)	The preference we use to take in information and determine the kind of information we prefer to trust	Sensing (S)	Preference to focus on the present, the details, and personal knowledge
		Intuition (N)	Preference to focus on the future, the big picture, and personal insights
Thinking (T) or Feeling (F)	The preference we defer to when we make judgments and decisions	Thinking (T)	Preference to make decisions based on impersonal, objective logic
		Feeling (F)	Preference to make decisions based on personal priorities and relationships
Judgment (J) or Perception (P)	Our preferred attitude toward the external world and how we prefer to orient ourselves to it	Judgment (J)	Preference to organize the external world and have decisions made
		Perception (P)	Preference to experience the external world and explore the options available

The emphasis of the MBTI instrument is not assessment of an individual's abilities or knowledge, but instead indication of an individual's preference in each dichotomy. The MBTI instrument indicates an individual's four letter type out of 16 possible type results (two preferences multiplied by four dichotomies). The MBTI type result of the instrument does not define an individual's chances of success in a particular field such as engineering or suggest potential compatible types for team formation, only the individual's natural preferences between the two potential ways of approaching each mental process and how that individual might prefer to function. Because of this focus on indication, rather than assessment, no type is inherently more valuable in engineering or on an engineering team. However, understanding their MBTI type can allow individuals to better articulate how their natural preferences affect their behavior within a team environment and better communicate those preferences to other team members.⁴ While MBTI type is considered an inborn trait of an individual, we all need and use all eight personality types at various times during our lives, especially the S, N, T, and F types which are all used to some extent in every decision making process we undertake. Development of the four non-preferred types is possible and generally increases with age. Environmental effects (such as requirements at work or responsibilities at home) can aid in this development and push an individual to engage their non-preferred type. Understanding their MBTI type can allow individuals to target this development process to the types they find most difficult to engage within a team environment and help team interactions go more smoothly.⁴

Unfortunately, many studies use MBTI type in ways in which it was not intended to be used, such as to assign individuals to teams or assess an individual's fitness for a particular career path.^{5,6,7,8,9,10} These studies often produce conflicting results surrounding the benefits of team diversity or homogeneity of personality type,^{5,8} which limits the possible impact of the research on engineering pedagogy. While some MBTI types may be statistically more likely to be the leader of a team or pursue a particular career, any type can excel in any position or field given the proper self reflection and knowledge of MBTI type. The value of this team training aspect of MBTI is often overlooked or mentioned as an afterthought.^{5,10} Further, because of this aspect of MBTI type, some studies discard the MBTI instrument in favor of other, more prescriptive instruments.^{6,7}

Rather than seek to use the MBTI instrument as a prescriptive assessment in team formation to circumvent difficulties in team dynamics, we propose to fill a gap in the literature on engineering teams by focusing on how MBTI type can be used as a team training tool in mitigating team miscommunications as they occur. We chose a chemical engineering capstone design course (referred to as "Senior Design" hereafter) as the context for our study. To investigate how MBTI type affects the success of student teams in Senior Design, we asked the following research questions: 1) how do the MBTI type make ups of successful and unsuccessful teams differ, 2) what difficulties do teams have related to MBTI type differences, and 3) how can knowledge of MBTI type help to mitigate team difficulties?

Methods

This study focuses on Senior Design because students work in teams throughout the semester and 50% of their final grades in the course are team-based rather than individual. Senior Design is a capstone design course taken in the final year of the chemical engineering curriculum at a

large, public university in the Midwest. In Senior Design, teams are made up of randomly selected students with specific attention paid not to isolate female students.¹¹ Female students make up one third of all students in the chemical engineering program. Teams have approximately uniform average GPA such that no team is made up of all 2.0 students or all 4.0 students, which limits the possibility that the average GPA of the team is an important factor in team success. Over the course of the semester, teams work together on projects in which they synthesize concepts from previous coursework to design a complete chemical process. Completion of these design projects requires teams to meet for significant periods of time outside of course meetings, both with and without the course instructor.

Data Collection. To understand how Myers-Briggs Type Indicator® (MBTI)¹ type make up affected team dynamics outside of course meetings, we took a document analysis approach during the Fall 2012 offering of Senior Design that included four data sources:

1. **MBTI type results** from a MBTI administration were used to determine students' individual MBTI type.
2. **Team interaction logs** were kept by the course instructor during four project checkpoint meetings with students during the semester. These logs included the instructors' perceptions of team dynamics and notes on potential difficulties the teams were having.
3. **Peer evaluations** were completed by students twice during the semester and turned in with team-based assignments. These evaluations were qualitative in nature and included students' perceptions of their team members' contributions to the team in addition to a self assessment of their own contributions. Students' general comments about the functioning of their team were used to determine whether or not a team was perceived as successful by the individual members of that team.
4. **Student work** in the form of team-based assignments and final team grades was used to determine whether or not a team was actually successful in producing quality work as defined by the course objectives.

All data collection was approved by the local Institutional Review Board (IRB #13209). All 16 teams in Senior Design were asked for their consent to collect data at two timepoints during the semester. The first timepoint occurred near the beginning of the semester after teams had been formed; students were administered the MBTI instrument and gave their consent to link their MBTI type with team interaction logs, team-based assignments, and final team grades. Students were told that their MBTI type would not be revealed to them until after they had turned in their final team assignments, but were offered free consultations with a certified MBTI administrator at that time. Concealing students' MBTI types and not providing team-related training around type to the students reduced the possibility that students would modify their behavior during team-based interactions because of that knowledge. The second timepoint occurred after students had turned in their peer evaluations; students gave consent to link their MBTI type with their peer evaluations. This timing removed the possibility that students' responses on peer evaluations would be affected by consenting to participate in the study. Teams were included in the study only if all team members consented to participate at both timepoints. Four out of the 16 teams (25%) met these criteria. Regardless of inclusion in the study, all students were offered the consultation about their MBTI type as compensation for participation.

Data Analysis. To protect students' confidentiality and remove the possibility that knowledge of which students participated affected the instructor's grading of the course, data

analysis did not begin until after final course grades had been assigned. We analyzed the data from a post-positivistic perspective in which we attempted to acknowledge and minimize our own biases in relation to the data. We used a thematic analysis approach¹² that included three phases. During the first phase of analysis, an author with MBTI Step I and II certification¹³ created a set of MBTI related codes to describe potential type differences and common difficulties seen in teams. After the initial coding of the data was completed, the MBTI administrator returned to the data for a second phase of analysis and looked for patterns in the codes. These code patterns combined to create the overarching themes for each of the four teams included in the study. During the final phase of analysis, the instructor of the course was asked to provide peer debriefing on the developing themes and verify that the themes represented the team dynamics of each team as seen from the instructor's perspective. With the instructor's perspective included, the MBTI administrator refined and finalized the themes.

Limitations. Based on anecdotal conversations between the MBTI administrator and the students during post-course consultations, some students had previously taken the MBTI and knew their type, had looked up additional information about MBTI type and teams after the initial MBTI administration, or had already taken other team-related/personality assessment instruments. These students may have used their prior knowledge to mediate difficulties in their teams more effectively than students with no prior knowledge of the MBTI instrument or related instruments. Because no data were collected pertaining to students' prior knowledge of their MBTI types, we cannot pinpoint which students might have entered the course with such knowledge or the extent of that knowledge. Further, because much of the information about the MBTI instrument has been made available to the public online, we have no way to prevent interested students from pursuing that information. These limitations on our understanding of individual students' knowledge and how that knowledge contributed to team success should be considered when comparing success across teams.

Results

We found that teams experienced difficulties related to all four of the MBTI dichotomies which were detrimental to team success. We first present both the actual and perceived success of all four teams and then step through a chronological description of the MBTI type related team dynamics of each team individually. Each team was assigned a letter identifier and all students were given pseudonyms. A table of students who were included in the study is provided in Table 2. Verbatim quotations from the written text of documents are indicated by quotation marks. Longer quotations are set off from the rest of the text with block indentation.

Table 2. Student participants by team, sex, and MBTI type.

Student	Team	Sex	MBTI Type
James	A	Male	ESTJ
Mary	A	Female	ESFP
Patricia	A	Female	INTJ
John	A	Male	INTP
Robert	B	Male	ESTJ
Elizabeth	B	Female	ESTJ
Jennifer	B	Female	ESTP
Michael	B	Male	ISTP
William	C	Male	ESTJ
David	C	Male	ESTP
Richard	C	Male	ENFJ
Joseph	C	Male	ENFP
Charles	D	Male	ESTJ
Thomas	D	Male	ESTJ
Christopher	D	Male	ISTP
Daniel	D	Male	ISTP

Team Success. The actual success of each team was determined by final team grades for each team. Final team grades are shown in Table 3. The grading scale in Senior Design was as follows: A+ = 87%, A = 82%, A- = 80%, B+ = 79%, B = 75.5%, B- = 74.2%, C+ = 72.2%, C = 67%, C- = 60%, and D+ = 59%. Students' perceptions of the success of their teams were determined using a combination of their general comments about the functioning of their team and their ratings of other team members' performance based on their expectations for those other team members. A breakdown of students' expectation related responses and the assigned ratings to each response can be seen in Table 4. Average ratings of other team members above a 3.0 were defined as a perception of success, equal to a 3.0 as a neutral perception, and below a 3.0 as a perception of failure.

Table 3. Final team grades in the Fall 2012 offering of Senior Design by team.

<u>Team</u>	<u>Final Team Grade</u>
A	A-
B	A
C	A
D	A-

Table 4. Students' responses to the question *Did this person: [response]* based on their expectations of each team member's performance.

Team (Team average)	Student (Average rating)	Possible Responses (Assigned Ratings)				
		<i>Substantially exceed expectations</i> (5)	<i>Exceed expectations</i> (4)	<i>Meet expectations</i> (3)	<i>Meet some expectations</i> (2)	<i>Not meet expectations</i> (1)
A (3.25)	James (2.7)		X	X		X
	Mary (3)		X	X	X	
	Patricia (3.7)		XX	X		
	John ¹ (3.7)	X		XX		
B (4.25)	Robert (4)		XXX			
	Elizabeth (5)	XXX				
	Jennifer (4)		XXX			
	Michael (4)	X	X	X		
C (4)	William ² (3)			XXX		
	David (4)		XXX			
	Richard (5)	XXX				
	Joseph (4)		XXX			
D (3.5)	Charles ¹ (3.7)		XX	X		
	Thomas (2.3)			XX		X
	Christopher (4)	X	X	X		
	Daniel ¹ (4)	X	X	X		

¹ This student's responses on the peer evaluations were sparse and their rationale for ratings was unclear based on those responses.

² This student provided the disclaimer "I held all team members to high expectations so it would have been very hard to exceed them." with his peer evaluation ratings and responded positively to other peer evaluation questions.

No final team grade fell below the A- range of the grading scale and no team average rating fell below a 3.0, as seen in Tables 3 and 4. Actual team success and the perceived success of each team based on peer evaluation ratings correlated well, as the actual grades of the two teams perceiving more successful project experiences (Teams B and C) were indeed slightly higher than the actual grades of the two teams perceiving less successful project experiences (Teams A and D). This trend is supported by some of the individual comments on peer evaluations pertaining to project success. Most students perceived their teams as being successful or neutral with the exception of two students, James of Team A and Thomas of Team D. James indicated that "...the project as a whole could have been better" and said, "[I'm] not satisfied in the least. [The project] was fairly disappointing overall." Similarly, Thomas explained that he "was very frustrated by the way [his] team operated" and said, "This team would have been totally directionless without me." Further, these two students were the only team members to rate any other team members as not meeting expectations, as seen by the bolded X's in Table 4. Both James and Thomas also perceived themselves as leaders of their respective teams, which potentially led to increased feelings of responsibility for the performance of their teams compared to other team members. This phenomenon is expanded upon in the team dynamics themes below.

T/F difficulties in Team A. In the first team interaction log for Team A, James surfaced as the leader of the team, which is common for ESTJs.^{14,15} However, in the second team interaction log, James appeared to the instructor as "probably delegating to others" more than leading and Patricia, an INTJ, seemed to be falling behind the other team members in terms of performance and engagement with the team. The instructor noted specifically "this odd tension" during the meeting. In the third team interaction log, the instructor removed James to see how the team interacted without him. The instructor indicated that both IN members of the team were less confident during the meeting as they were "very dependent on notes" and "presented less" than their remaining ES counterpart. However, without James there was no mention of the tension from the previous meeting. Team A's first set of peer evaluations revealed additional insights into James' leadership of the group. John mentioned that "[James] gets so involved in a task that he charges ahead into the project as an individual instead of with the team" and asked that he "treat the project less as his own and more as the group's." Mary felt that James "does [the project] all on his own" and noticed their T/F type difference when she requested that he "have a little bit more trust in the team and give more responsibility to others." James, on the other hand, indicated that all three other team members could not be trusted, using statements that represent his T preference. He mentioned Patricia's work as "usually incomplete or wrong" and that "she cannot be trusted to do quality work." He focused on Mary as a number rather than a person, stating that "when I work with Mary on the project it feels like 1.5 people are working instead of two" because "she does not work very efficiently." He explained that John "simply does not get work done," again focusing on the work and efficiency, rather than the person behind the work. However, he did note this aspect of his personality by mentioning that he has "a tendency to quickly lose trust or patience with others" and that he "could definitely give people more of a chance to redeem themselves." He also expounded on his leadership methods and reflected on other ways he could approach work quality difficulties with team members:

I could also force them to do more of the work. I think at this point they know that if all else fails they can wait and I will take over the reins of whatever they are working on when I am sufficiently fed up with their effort/quality of work.

This expectation lowering for team members (rather than holding team members to a high standard and providing support for them to meet those expectations) became a vicious cycle of underachievement and led to James leaving his team members behind as the project continued. In the third team interaction log, the instructor mentioned that James was “dominating [the] group” as an individual “work horse” rather than a supportive leader. The final peer evaluations revealed a slight shift in James’ leadership toward a more trusting approach to other team members. Mary noted that “after update 3 [James] was **much** better at trusting [the other team members]” (emphasis in original), but wished that he would value the human element of the team more, including his own needs:

[James] could improve his performance by being more positive and realizing that sometimes people have other things to do so we cannot focus our 100% full attention on the project at the time. He could also give himself a break once in a while, he deserves it.

James seemed to reflect on the weaknesses in his leadership methods and consider ways in which to improve in the future:

I suppose one thing I could do is not coddle people as much. There were times when I was too willing to do something for someone instead of put up with [other team members’] complaints. The result was me stretching myself too thin and working myself to the bone while simultaneously not forcing them to just do stuff.

He also showed signs of developing his non-preferred P type by valuing John’s contributions to the team despite their J/P type difference:

[John] has a tendency to do things last minute or at a slow pace. This is okay unless your last minute work or slow pace begins to hold up other portions or precludes you from helping on other aspects of the project. Once John buckles down to do something, you know it is going to get done thoroughly and get done right.

Unfortunately, the damage appeared to be done in terms of James’ lowered expectations for some team members. Patricia turned in her peer evaluation late and was noted by all three other team members to be disengaging from the project throughout, but especially in the final weeks. John mentioned that she “wasn’t thorough with her work” and James expanded on this lack of prioritization of the project:

Patricia was the only member that in no way prioritized the project. Her thought process was clearly that someone else would take care of everything. She didn’t care about it or have any interest in it and I believe that was reflected in the quality of work she put in.

Overall, more development of his non-preferred F type (possibly by taking cues from Mary's more positive, people-centered approach to the team) would likely have benefited James as a leader and mitigated some of the team dynamic difficulties experienced by Team A.

ST similarity and E/I difficulties in Team B. All four members of Team B shared the ST type pairing, which is more common for individuals who become managers, engineers, or pursue careers in technical fields.¹⁴ During the first and second team interaction logs for Team B, Robert, an ESTJ, appeared to be the developing leader of the team. The instructor indicated that he was "outgoing, confident, and leader type." Elizabeth, also an ESTJ, brought "great atmosphere" to the meeting and no glaring problems with team dynamics were noted by the instructor. The team seemed to function well together during the third team interaction log, but the only member of the team with an I preference, Michael, was perceived by the instructor as "a little self conscious." In Team B's first set of peer evaluations, several team members mentioned Michael's lack of confidence. Jennifer suggested that Michael could "try and build his confidence [because] he has many great thoughts that he needs to make sure are heard." Robert noted that for Michael, "having more ownership [of his part of the project] will make others more confident in his work, seeing that he is passionate about it." Despite these considerations about Michael's personality, all the team members seemed to value one another's contributions to the team with the vast majority of responses to the question *How excited would you be to work with him/her again in a future team?* being "He/She is among many individuals I have met that would be pleasant team members." Further, the two ESTJ team members appeared to be working in tandem to lead the team and build strong team dynamics. Robert provided direction for the team by considering the ST viewpoints of all team members:

I take everyone's opinion into consideration as we make decisions. Many times other members' ideas are better than mine and I always want us to move forward with the best idea.

Possibly drawing upon development of her non-preferred F type and filling in the missing F preference on the team, Elizabeth focused on creating a positive team atmosphere:

I think I'm great at providing a good attitude.... Listening to others is definitely something I value, and I'm always asking myself whether I'm really listening to others or not. I am never rude to other members of the team, and work hard to make sure that the team dynamic is 'gelling.'

The last team interaction log and final peer evaluations indicated that the project was a success for the team. Again, the majority of responses to the question *How excited would you be to work with him/her again in a future team?* were "He/She is among many individuals I have met that would be pleasant team members" with an increase in "He/She is one of the best team members I've worked with; I would seek him/her out in future projects." Elizabeth specifically said that she was "sad to not be working with [Jennifer] anymore on this project" as an additional comment beyond the responses requested in the peer evaluation. Robert's leadership of the team was seen as supportive, rather than oppressive, by the other team members. Jennifer commented about Robert's leadership:

[Robert] should continue to take the lead [because] he is a natural born leader. He was not, however, overbearing and certainly let everyone contribute an equal amount to the project. He values everyone's opinions with equal weight.

Elizabeth corroborated this sentiment by saying "Robert is a clear leader; he has a vision for where he wants to go, and his decisions are always well supported. We couldn't have done the project without him!" Possibly because he was the only team member with an I preference, Michael may have felt overpowered by his E type team members and disengaged from the group slightly. While his peer evaluation responses were once again positive about the other team members, they were also almost exact copies of his responses in the first set of peer evaluations. Overall, knowledge that Michael might need more internal processing time during team meetings and might therefore be slower to respond in team discussions with his thoughts would likely have helped other team members facilitate his contribution to the team and engage him more thoroughly in the project. However, the ST type pairing commonality among all team members allowed for straightforward communication of thoughts and ideas and resulted in an overall positive team experience for Team B.

Mitigating ST/NF difficulties in Team C. From the first team interaction log for Team C, the instructor noted that both NF team members were "a little intimidated by William and David," who both shared the ST type pairing. While no clear leader was present during the first team interaction log, by the second the instructor described William, the ESTJ, as "the big brother" who would step in when others were struggling and lead the team. Richard, the ENFJ, appeared to have improved since the first team interaction log. On the other hand, Joseph, the ENFP, appeared to be "coasting a bit" during the second team interaction log, but showed improvement during the third. The improvement in team cohesion was elucidated in the first set of peer evaluations for Team C. William discussed a turning point in the team's dynamics as well as his leadership methods:

Up until the week of our second update, I had felt as though I had been prodding the team in the right direction, making sure that what we did was thorough enough and that we had sufficiently considered all options. The week of the second update however, I really had to lean on my team as I was gone from school all week and had a huge time commitment the weekend before. This was when I felt as though we really became a team.

Because of his life circumstances, William went from a more controlling leadership style to trusting the other team members to meet his high expectations. He highlighted their contributions graciously, such as by saying that Joseph was "great with communicating and ensuring that we have all our ducks in a row before we submit anything." He valued Richard's F preference as the driving force in building the team:

[Richard] really helped to keep us together and make sure that we had effective channels of communication. Without Richard, we would be a group of individuals. Coming off of three straight nights of 4 hours of sleep and me about ready to pass out at our group meeting, I said, 'I'm sorry I just haven't been able to get my stuff all done.' Richard just put a hand on my shoulder and said, 'It's cool man, now we're a team.' That means a lot and I really appreciated it.

He also responded to the question *How excited would you be to work with him/her again in a future team?* with “He/She is one of the best team members I’ve worked with; I would seek him/her out in future projects” for every other member of the team and included an additional note to the instructor: “Thank you very much for such a great team.” The other team members mirrored these types of sentiments. Richard indicated that the team members “felt that we were finally a team [before the second update]” and David mentioned that the team “is a very trusting environment, where everyone knows the work will be done on time.” By the last team interaction log, the instructor perceived the team’s increased cohesion by stating that “they are all working well together.” The final set of peer evaluations provided similarly positive views of the team as a whole. William reflected on his growth as a leader and indicated that he “could be more trusting of [the] team and micromanage less,” but “as the project went on...[he] felt he grew in that regard, allowing others to make their parts their own.” Richard corroborated William’s reflection by saying “William over the semester has improved his listening skills” and “[William] has been very accommodating and values every other group member’s opinions.” Because William increasingly used supportive leadership methods during the semester and valued Richard’s F preference, he effectively mitigated the ST/NF difficulties the team experienced at the beginning of the semester and facilitated a successful team overall.

EJ/IP difficulties in Team D. The instructor was disappointed by Team D’s performance during the first and second team interaction logs and “expected more from seniors.” However, the team seemed “to be getting along,” despite being perceived as “unmotivated and careless” by the instructor. The two ISTP team members appeared to be “coasting,” while the two ESTJ team members were described as “work horses,” with “no real leader” in the hierarchy of the team. The overall team dynamic had not changed significantly by the third team interaction log. The instructor noted that the team was “working well together,” but still “unmotivated.” In the first set of peer evaluations for Team D, Thomas revealed that the team might not be getting along as well together as the instructor perceived. He indicated that the other ESTJ, Charles, “called a meeting for just me and him to finetune...the [project] model” without the two ISTP members. Thomas also indicated himself as the leader of the team and reflected on his approach to the general laziness of his teammates:

When other group members are satisfied with the amount of work that is done but I think there is more to be done, I should be more vocal about my disagreement rather than just ‘going with the flow.’

Thomas expanded on Daniel’s perceived laziness by highlighting Daniel’s P preference and noticed that “sometimes [Daniel] doesn’t take specific deadlines seriously.” Thomas’ E/I type difference with Christopher made his participation in team discussions appear lazy because he “often just sits silently throughout entire meetings.” Both Christopher and Daniel perceived the disconnect between themselves and the two ESTJ team members. Christopher noted that Thomas made him “feel like [his] work is not totally trusted” and asked that Charles “not work so far ahead on the ChemCAD model” because “ChemCAD is one of the most important parts of this project so we should all do it.” During the last team interaction log and in the final set of peer evaluations, team dynamics further declined. Thomas showed signs of burning out from taking on too much responsibility for the team because of their perceived laziness:

I felt like I gave my teammates too much slack, and if I were to do it again I would get a little meaner to make them do the work when it was assigned. In the beginning I tried to be understanding and lenient but that didn't really pay off. I decided that it wasn't worth all the effort to corral them into doing the work and I would rather take the work into my own hands than risk a mediocre deliverable. This strategy had a detrimental impact on me personally as I have never felt so burnt out by a class.

However, Christopher expressed a drive to contribute to the team and suggested that "Thomas should give more of the work to others" because "everyone needs to carry their own weight." Unfortunately, the damage was already done and Thomas had alienated the rest of team, even Charles, the other ESTJ. Charles' responses to questions in his peer evaluation were sparse and Thomas indicated having "to really push and cajole him into doing the work assigned to him," which may have stifled Charles' own personal plan for his contributions to the project. Overall, Thomas' (and the instructor's) perception of the two ISTP team members' personalities as unmotivated led to Thomas employing controlling leadership methods that exhausted him and alienated the rest of his team.

Theme Summary. As a preface to the discussion, a brief summary of the success and team dynamics of each team is provided in Table 5.

Table 5. Success and team dynamics theme summaries by team.

Team	MBTI Type Make Up	Females to Males	Final Team Grade	Team Success Rating	Team Dynamics Theme
A	ESTJ ESFP INTJ INTP	2:2	A-	3.25	ESTJ leader did not value representation of his non-preferred types (F, I), used controlling leadership methods, alienated his team members, and burnt out
B	ESTJ ESTJ ESTP ISTP	2:2	A	4.25	ESTJ leader's use of supportive leadership methods and shared ST type across team members streamlined communication and led to a positive team experience
C	ESTJ ESTP ENFJ ENFP	0:4	A	4	ESTJ leader's use of supportive leadership methods and valuing representation of his non-preferred types (N, F) led to a positive team experience
D	ESTJ ESTJ ISTP ISTP	0:4	A-	3.5	ESTJ leader did not value representation of his non-preferred types (I, P), used controlling leadership methods, alienated his team members, and burnt out

Discussion

In all four teams, an ESTJ team member surfaced as the leader of the team. Because of this homogeneity of leader MBTI types, most studies would predict similar leadership outcomes for all four teams.^{9,16} However, that outcome was not the case in our study. For Teams A and D, the ESTJ leader ignored the necessity for F preference representation on the team and failed to trust in other (often I or P type) team members' ability to complete their assigned portions of the project, which led to team members disengaging, the leader himself "burning out" from the stress of responsibility, and an overall negative team experience. On the other hand, for Teams B and C, the ESTJ leader valued the F preference representation on the team and employed supportive, rather than controlling, leadership methods, which led to increased perceptions of success among individual members of the team and an overall positive team experience. Further, all four teams had the same ratio of J and P types. The P preference representation and type make up similarity should have facilitated similarly successful teams,¹⁷ but again, that was not the case in our study. Teams B and D had nearly identical MBTI type make ups and all members shared the ST pairing on both teams, yet the success of the teams was quite different, contrary to literature.⁵ Even the sex make up of each team did not qualitatively seem to affect the success of the team. Teams A and B had the same ratio of females and males with starkly different outcomes, again contrary to literature.⁸ These differences stemmed not from differences in team make up, but from the differences in the value placed on non-preferred type representation by individuals on each team. The higher the value team members placed on non-preferred type representation, the more successful the team was overall.

Additional support against using MBTI type as a prescriptive tool comes from the fact that the MBTI instrument is not immune to falsification or improper reporting of MBTI type. Individuals can use knowledge of how the instrument is scored and the types of questions that pertain to each dichotomy to produce any type combination they desire. Societal pressures can push individuals to answer questions in ways they see as more socially acceptable or applicable to the context in which they are taking the MBTI instrument.¹⁸ Students may have subconsciously felt the pressures of the engineering discipline and the focus on logic (T), details (S), and planning (J) as they responded to each question on the instrument, which could have resulted in a bias in their reported types and inaccurate results from any quantitative comparison of their success in the course. Further, using an improperly reported MBTI type to categorize students into teams undermines the goal of arranging team make up to produce successful teams. This limitation of the MBTI instrument makes it a more effective training tool than an assessment tool.

Some studies advocate for the use of the MBTI instrument as a team training tool, but only as an afterthought of a more assessment driven study.^{5,10,17} Instead, we advocate for research on the effects of using the MBTI instrument as a team training tool and not as an assessment tool. Coaching students on how to value individual differences in type preference and address lack of type representation on a team, most notably in relation to T/F difficulties in the case of this study, could help to mitigate the miscommunications teams experienced. For example, training students about how any decision making process requires engaging all four of the S, N, T, and F types could have addressed the bulk of Team A's difficulties during the project. Another example seen in this study that is often seen in industry and business is the conflict between J

type leaders and P type team members because of misunderstandings of the workflow differences between the two types. J type leaders such as Thomas from Team D perceive P type team members as lazy or unconcerned about deadlines, but P type team members like Christopher can possess just as much drive and motivation as their J type counterparts. Illustrating these MBTI type related difficulties can help students be more reflexive and self aware as they work together in engineering teams and ultimately result in more positive team experiences.

Conclusion

Personality type is not a clear cut definition of who an individual is or how an individual will behave in a particular situation; rather, it is a complex combination of an individual's inborn personality traits and the environmental effects that shift those traits as they gain life experiences. Because the MBTI instrument is intended only to provide a conduit for individuals to better understand themselves and others, trying to predict team success based solely on the MBTI type make up of the team is an educated guess at best and woefully inaccurate at worst. From an extensive literature review on the predictive power of MBTI type on success, "It is clear that efforts to detect simplistic linkages between type preferences and...effectiveness have been disappointing. Indeed, given the mixed quality of research and the inconsistent findings, no definitive conclusions regarding these relationships can be drawn."¹⁵ This lack of definitive conclusions about MBTI type in relation to success and effectiveness after years of research implies that something about our approach to studying the phenomenon must change. Instead of seeking to categorize students into more effective teams and ignoring the complexities of team dynamics related to personality type, future studies into the effects of team training based on MBTI type for engineering students could elucidate these complexities and give further insight into how students can be trained more effectively to function in team environments.

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